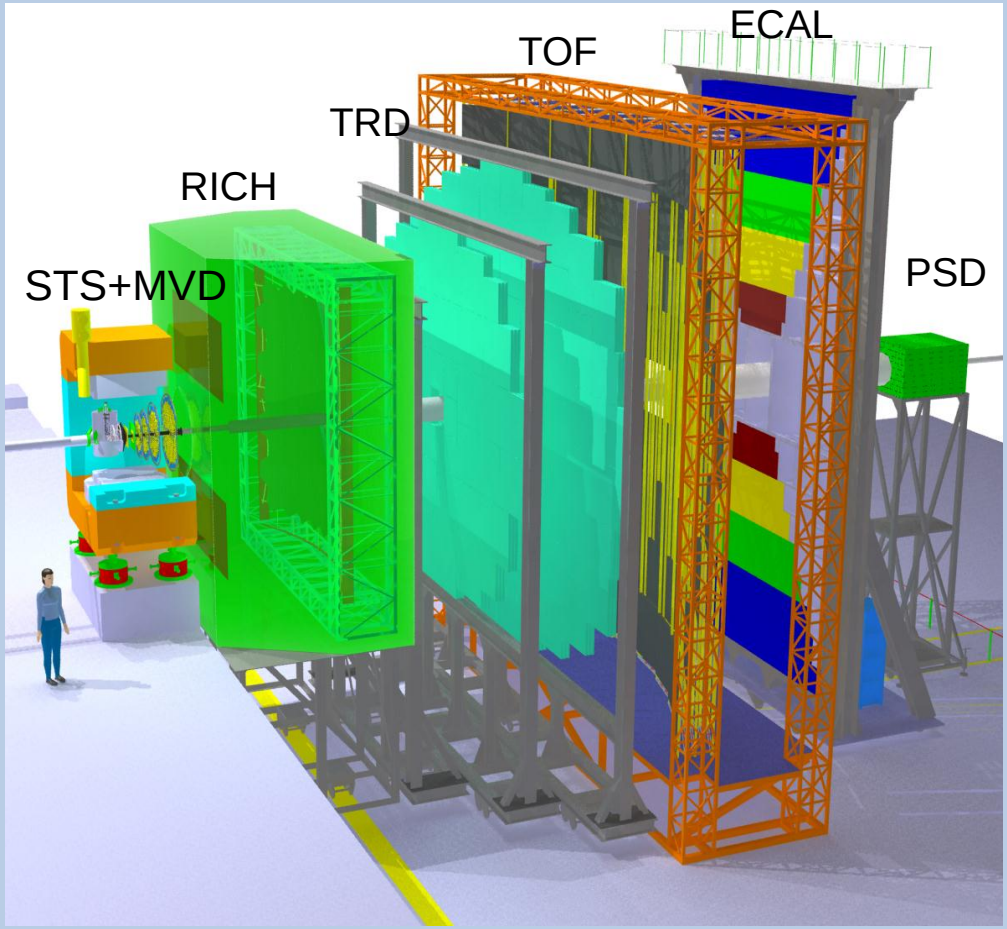
Status of Reconstruction in CBM

Volker Friese
GSI Darmstadt

4th International Workshop for Future Challenges in Tracking and Trigger Concepts
28 November 2012, CERN, Geneva

Reminder: experimental setup

Electron + Hadron setup



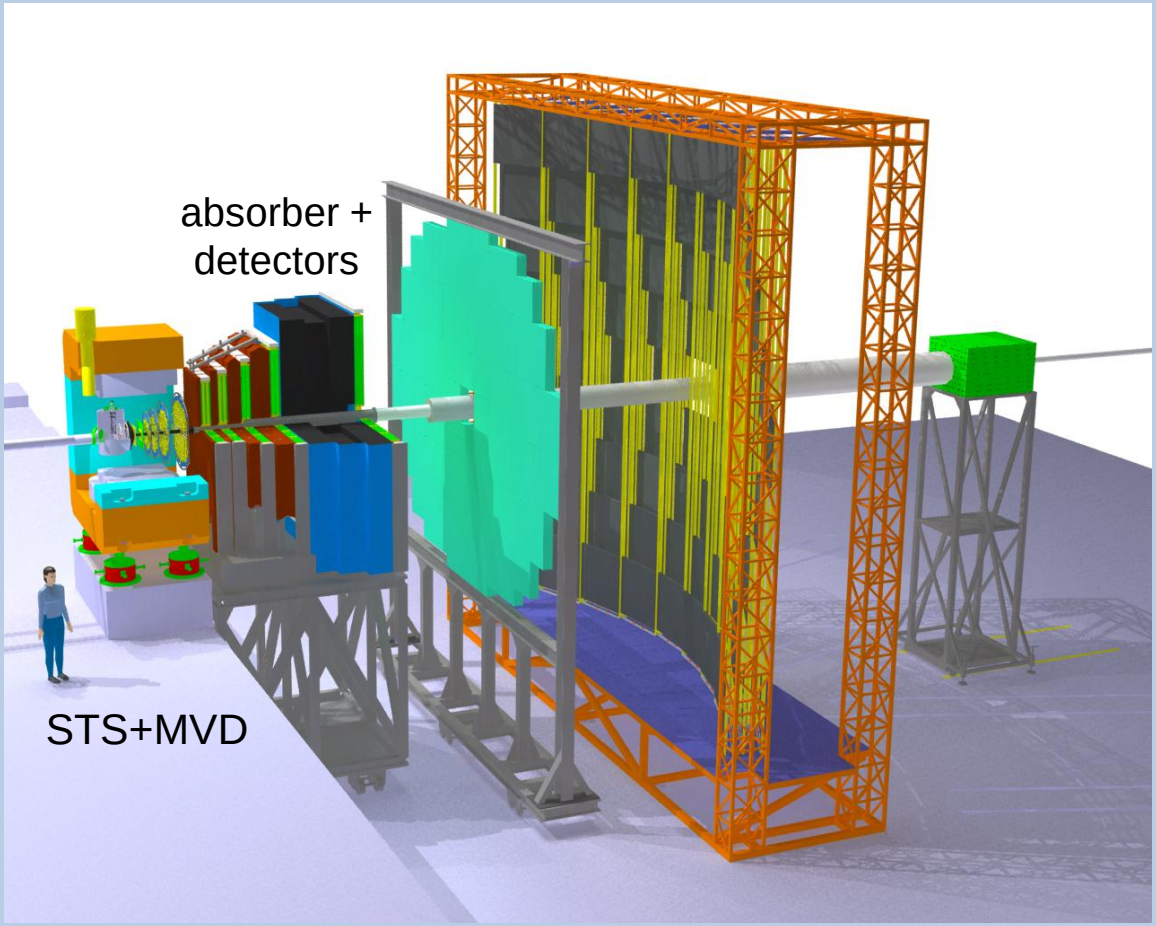
Measurement of hadrons (including open charm) and electrons

Core tracker: STS (silicon strip detectors)

Micro-vertex detector for precision measurement of displaced vertices

Reminder: experimental setup

Muon setup



Measurement of muons (low-mass and charmonia) in active absorber system

CBM Project Status

- Approved experiment at FAIR
- Detector design consolidated
- Prototypes of all sub-systems tested in beam
- FAIR construction started
- Installation and commissioning 2017
- First operation 2018

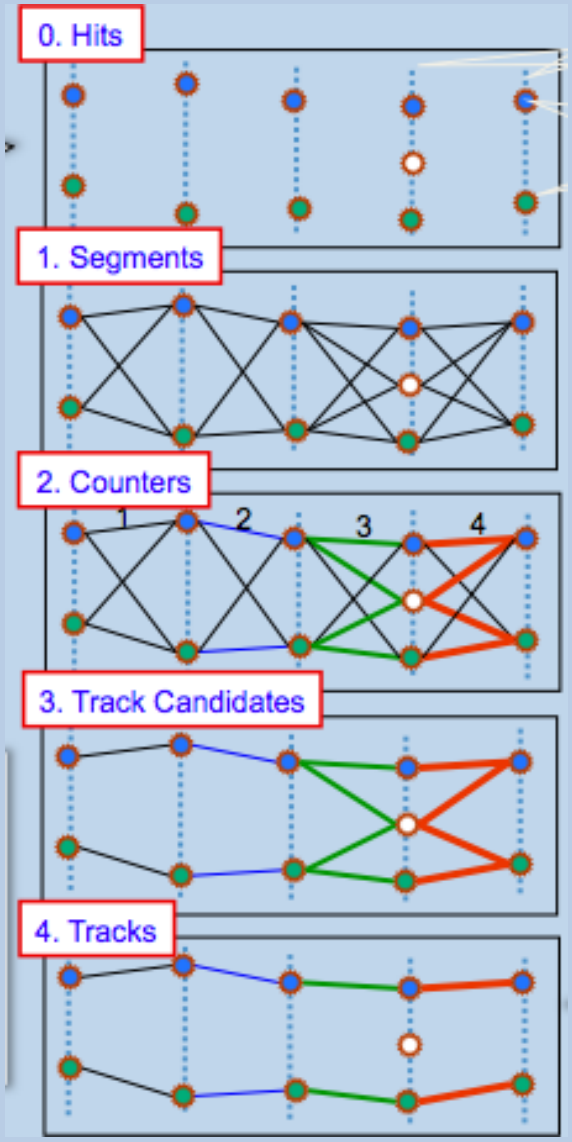
CBM: What's Peculiar

- Heavy-ion collisions at very high interaction rates (up to 10 MHz)
- No hardware trigger
- Free-streaming data; no a-priori event association
- Online reduction of raw data by a factor of up to 1,000
- Fast online reconstruction and analysis is indispensable

Tasks for Online Reconstruction

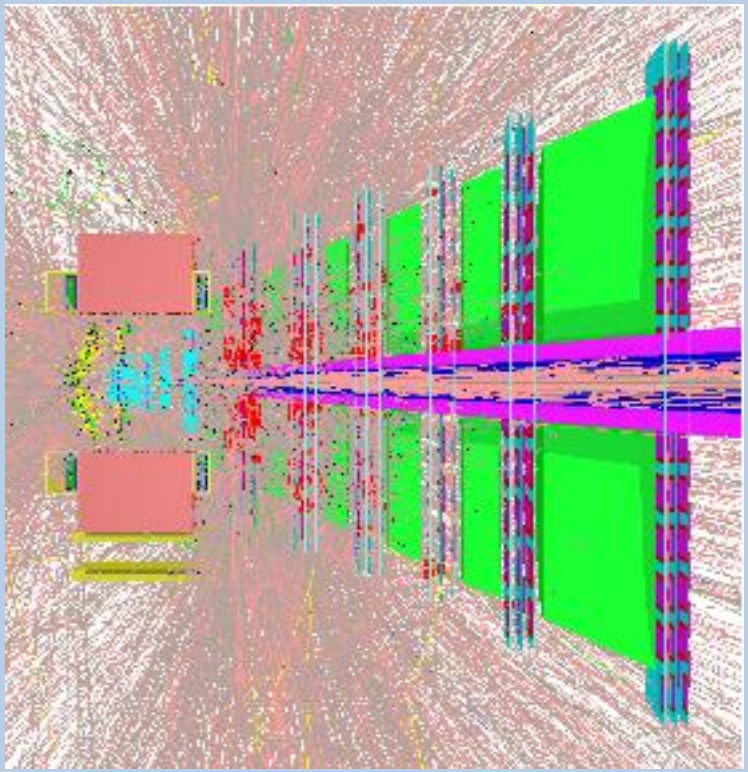
- Track reconstruction in STS
  - Cellular Automaton
- Track reconstruction in TRD
  - Track following
  - Cellular Automaton
- Ring finding in RICH
  - Hough transform
  - Elastic Net
- Matching RICH ring, TOF hit and ECAL cluster to tracks
  - by proximity
- Analysis of trigger signatures and data selection
  - see presentation by I. Vassiliev (Friday morning)

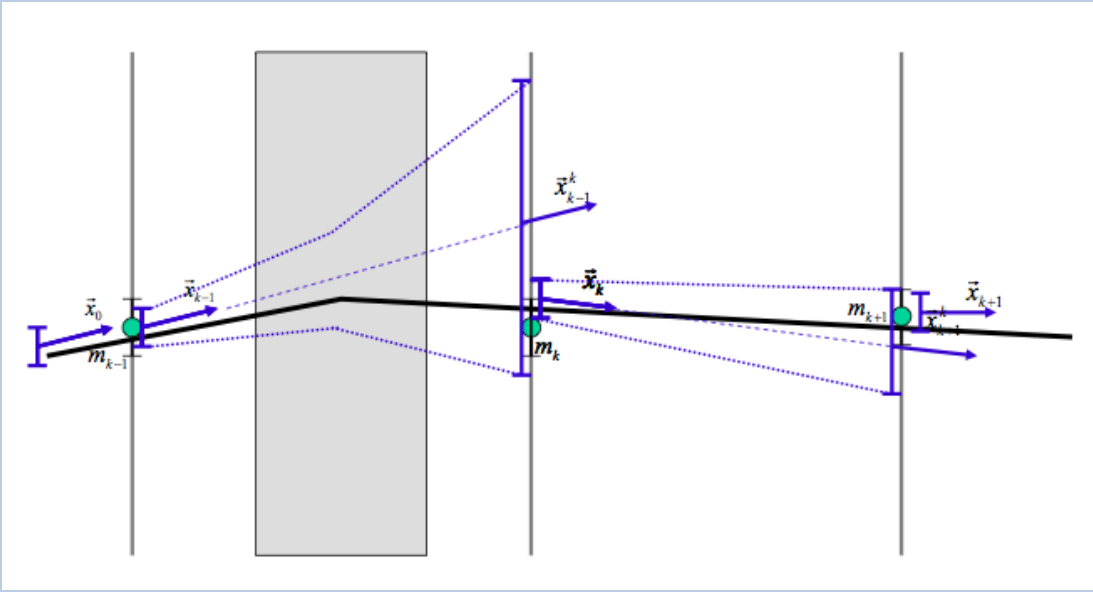
Track Finding in STS



- CA approach established over years of development
- reconstruction time on ms level
- see presentations by I. Kulakov and V. Akishina (tomorrow afternoon)

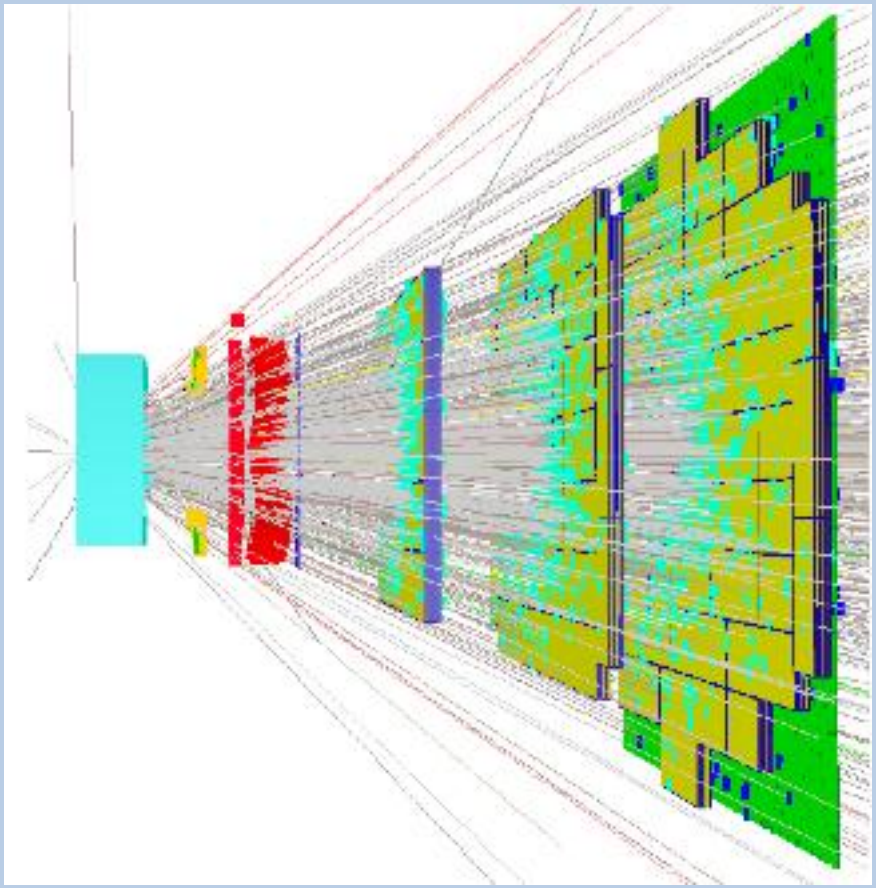
Tracking in the muon detector





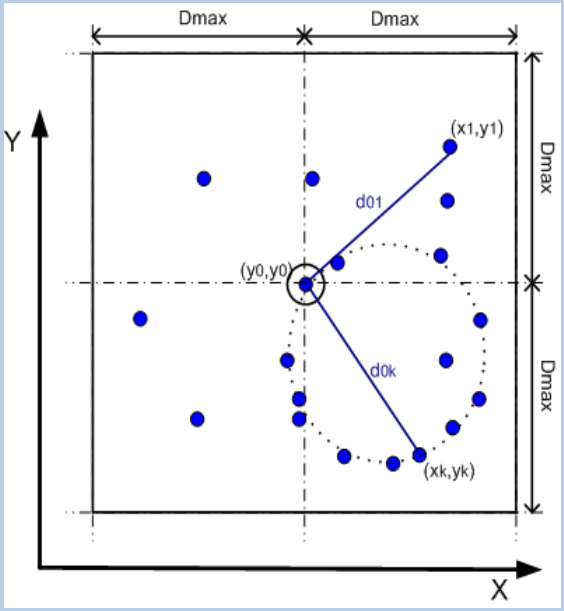
- „Active absorber“ system: absorbers are interlayed with 6x3 detector layers
- Tracks from STS are used as seeds
- Track following with Kalman Filter
- Propagation with 4th order Runge-Kutta
- Hit association: nearest neighbour / branching / weighting

Tracking in the TRD

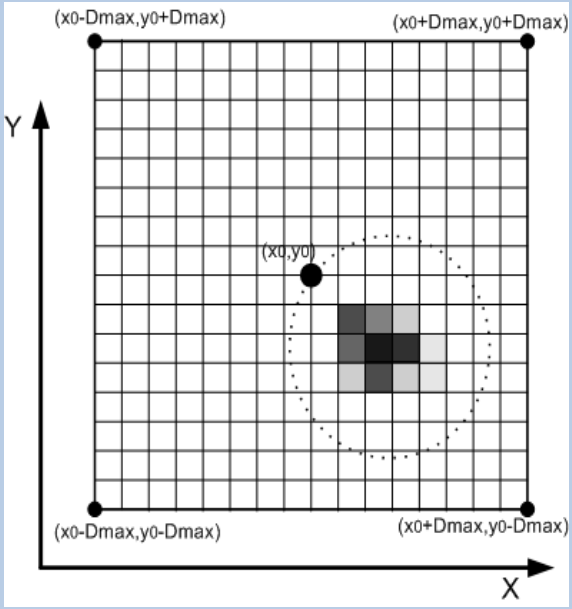


- 10 - 12 identical layers
- Track finding similar to tracking in the muon detector (track following + Kalman Filter)

Reconstruction of RICH rings

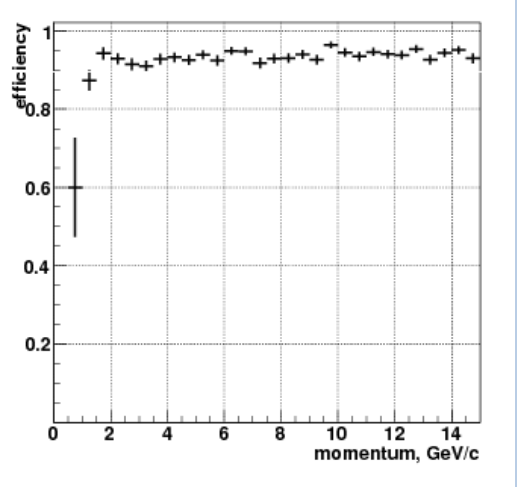


Hough Transform



UrQMD, central Au+Au @ 25 AGeV + 5 e^+ + 5 e^-

- Ring finding by localised Hough Transform (pre-selection of hits)
- Ellipse ring fitter
- Rejection of fake rings by quality criteria (ANN)
  - number of hits on ring, χ^2, largest angle
  - half axes, rotation angle
- Efficiency 92 %, fake rings 3.5 / event



Status CBM Online Reconstruction

- All algorithms optimised w.r.t speed and parallelised
- Not many changes since last workshop in February 2012

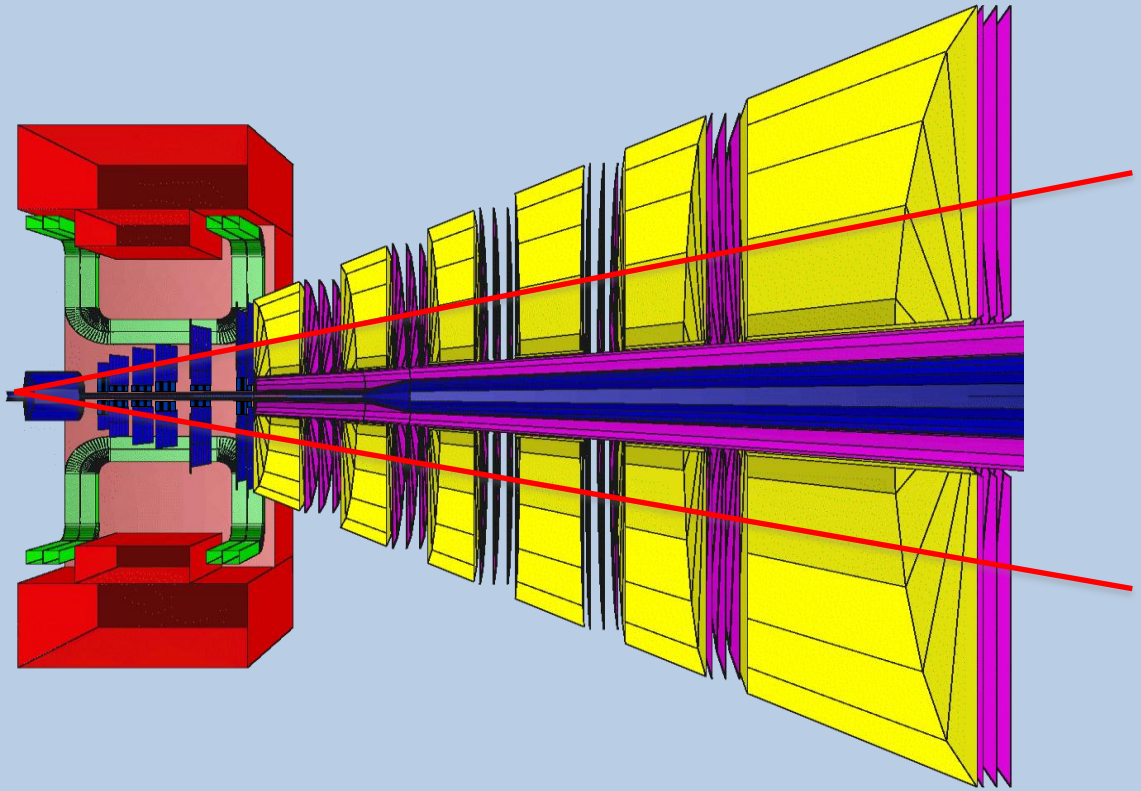
Open issues:

- Reconstruction starts with space points. How to arrive there from raw data?
- Implementation on which hardware?
  - CPU / GPU?
  - GPU: ATI / NVIDIA?
  - language: OpenCL / CUDA?
- Implementation of fast software triggers?

Trigger Signatures

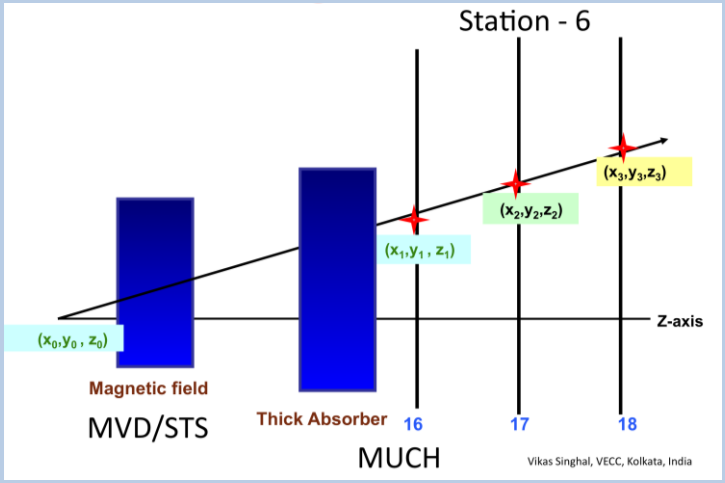
- Signatures vary qualitatively:
  - local and simple: $J/\psi \rightarrow \mu^+\mu^-$
  - non-local and simple: $J/\psi \rightarrow e^+e^-$
  - non-local and complex: D,Ω->charged hadrons
- For maximal interaction rate, reconstruction in STS is always required (momentum information), but not necessarily of all tracks in STS
- Trigger architecture must enable
  - variety of trigger patterns (J/ψ: 1% of data, D mesons: 50% of data)
  - multiple triggers at a time
  - multiple trigger steps with subsequent data reduction

Trigger in the Muon System



Signature: Two main-vertex tracks after the last absorber

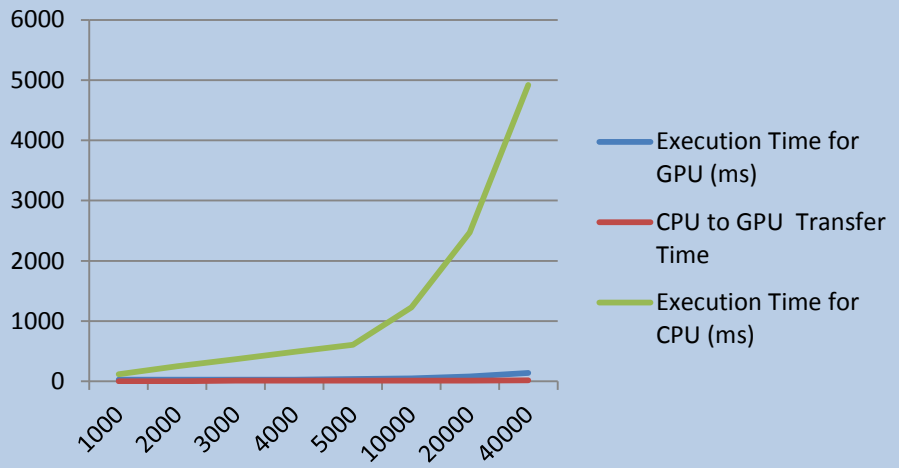
MUCH Trigger Implementation in CUDA



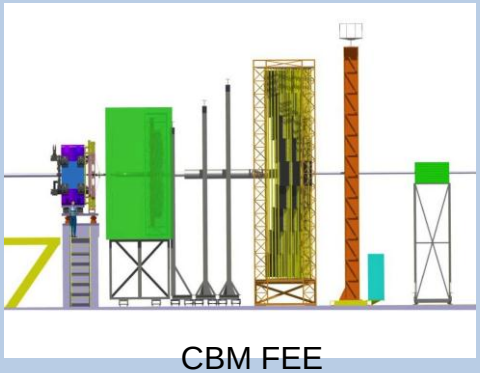
BSF:- Total Input Events / No of Background event survived after Threshold

Threshold	Events Survived (1000 Events)	BSF
A	431	2.32
B	120	8.33
C	100	10
D	41	24.39

- Fit triplet by straight line and extrapolate backwards to target
- Implemented in CUDA and tested on NVIDIA Tesla

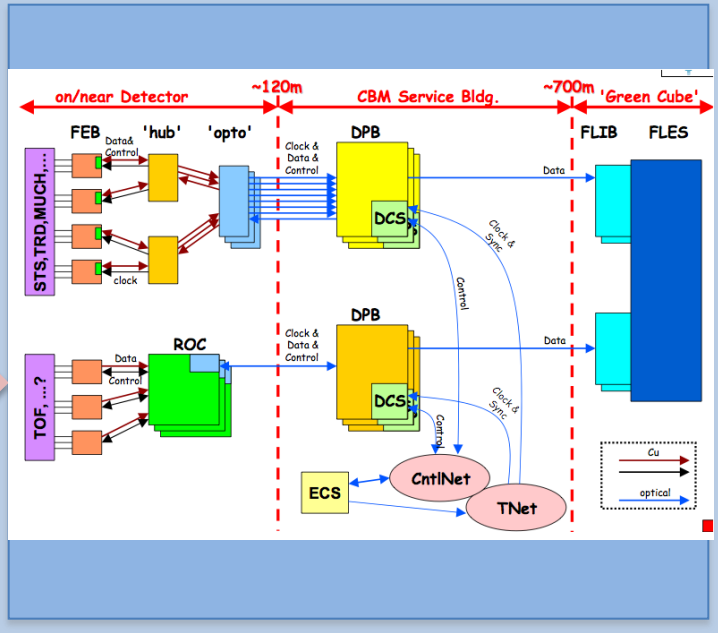


Towards Online Data Processing



CBM FEE

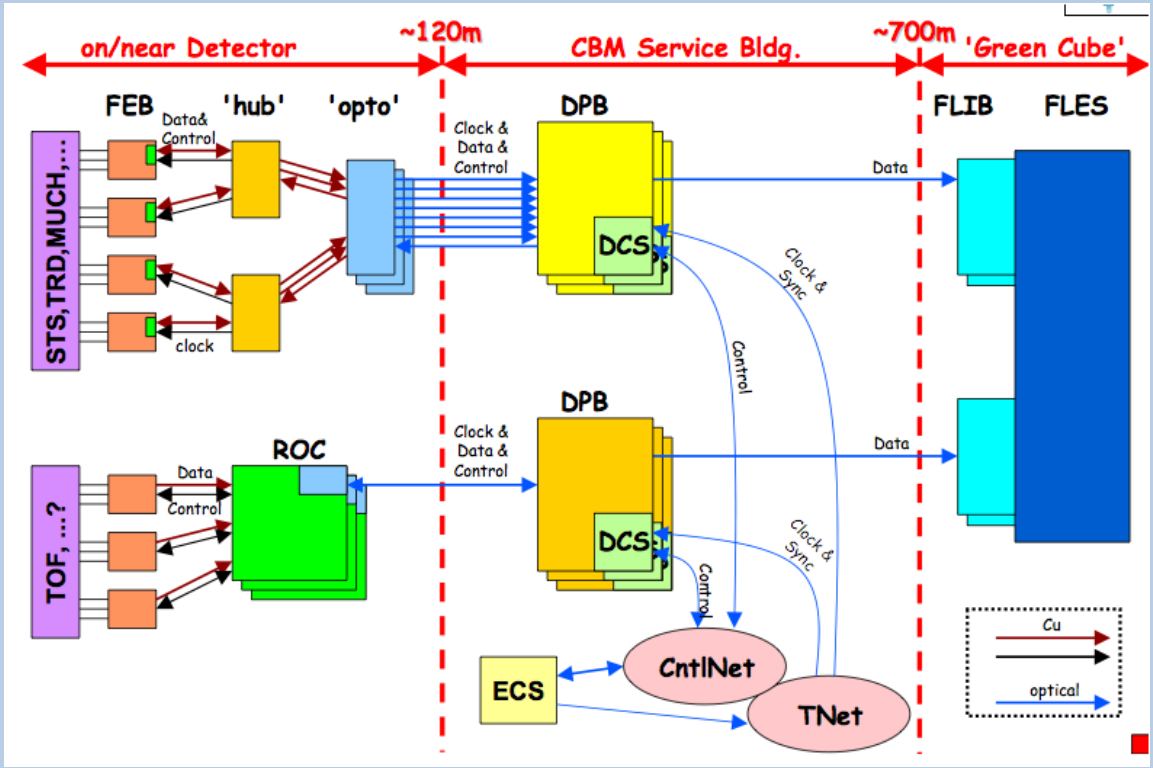
1 TB/s



1 GB/s

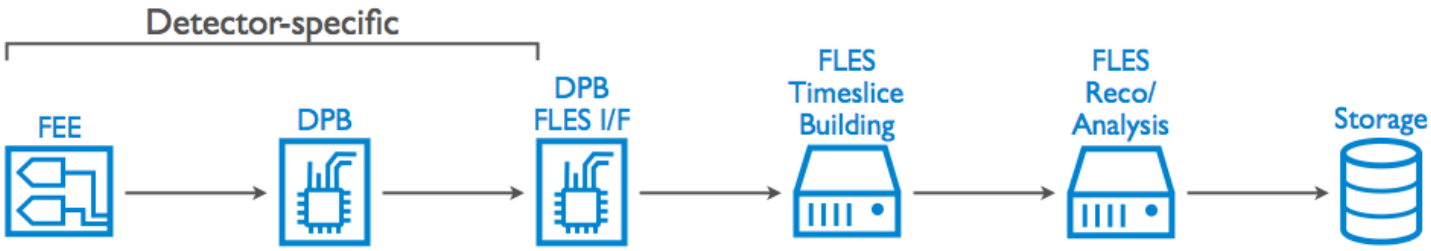
Mass Storage

Online Data Flow



- FPGA (DPB, FLIB): Data aggregation, pre-processing (e.g., cluster finding), time slice building
- CPU/GPU (FLES): (Partial) event reconstruction, data selection

Data Formats



Detector **Message** Format	Detector **Data** Format	Microslice Containers	Timeslice Containers	Storage Data
• Data points, epoch markers, etc. • Very small fundamental messages • Mostly specified by FEE ASICS	• Detector data for a constant time interval • Preprocessed or raw data • Self-contained • Data contents of an MC	• Lightweight container format • 128-bit header • Preliminary specification available	• Timeslices for analysis • Concatenation of microslice containers • Index table	• Data of selected events • Possibly ROOT files

Some Way Yet To Go

- Data processing on a FLES computing node is only one part of a complex online system
- The input to a computing node will be a „timeslice“ data container, with the raw data of all detectors within a given time interval
- Track reconstruction is only one part of the problem:
  - data preparation (creation of space points from raw data)
  - event association

Enough of work for the years to come!